

EXHIBIT E

FOUNTAIN CREEK REACH 7

AQUATIC RESTORATION PLAN NARRATIVE

Aquatic Assessment  
&  
Habitat Enhancement Plan  
Fountain Creek - Memorial and Mansions Park  
City of Manitou Springs  
El Paso County - Colorado



Prepared by



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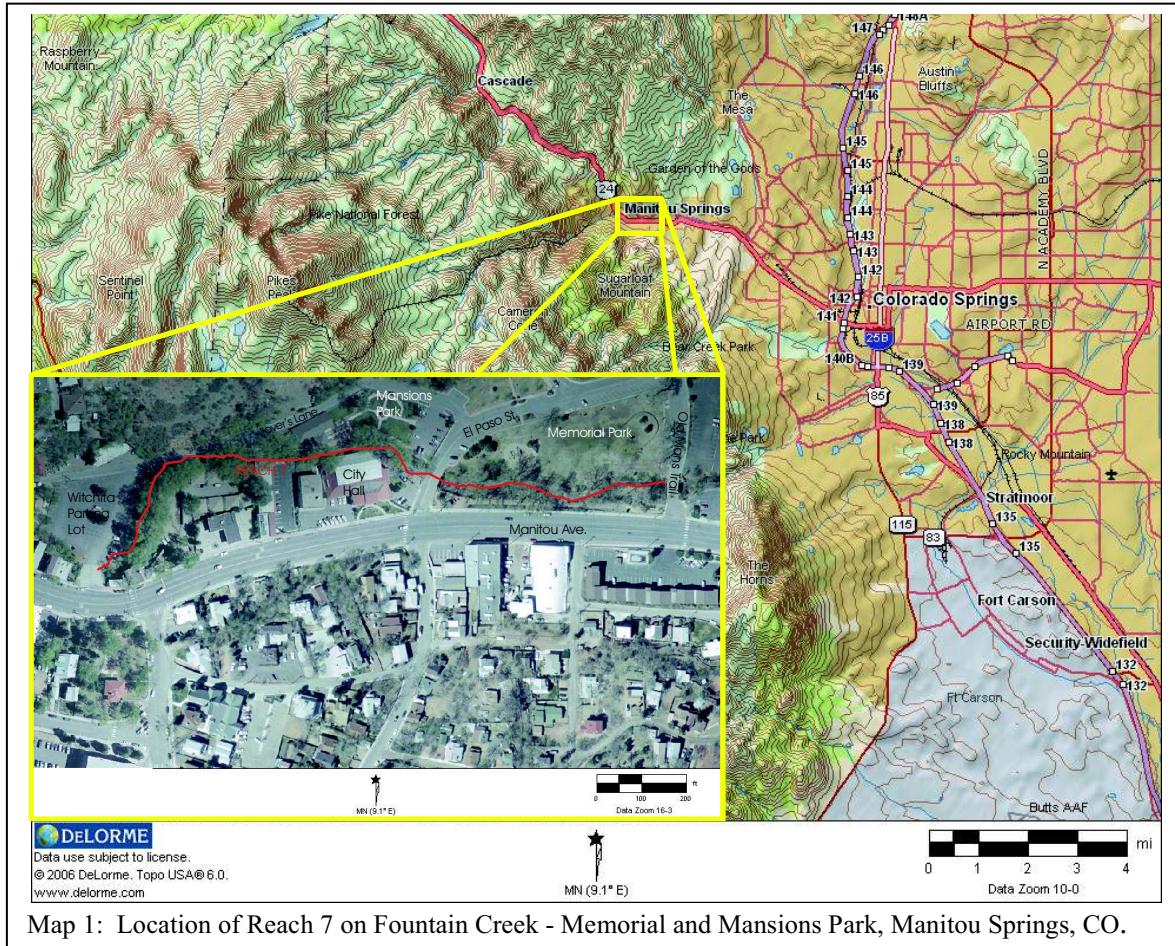
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In January 2009, FIN-UP Habitat Consultants, Inc. was contracted by the City of Manitou Springs to conduct an aquatic habitat analysis and habitat enhancement strategy for a segment of Fountain Creek within Memorial and Mansions Park, in the center of the city. The stream within the park is approximately 1,500 feet in length, consisting of a moderately entrenched channel flowing through a cottonwood and alder dominated floodplain in Memorial Park, and a severely confined channel bounded by concrete retaining walls and building foundations through Mansions Park. An aquatic assessment was conducted within the project area during the 1<sup>st</sup> week of February, 2009, and the results of this study are summarized in this document.



## Watershed and Hydrology

The headwaters of Fountain Creek consist of several perennial streams with headwaters in the city of Woodland Park and along the north slope of Pikes Peak. The watershed extends downstream to the confluence with Monument Creek near downtown Colorado Springs. The aspect of the watershed is mostly southeasterly. The headwaters of Fountain Creek watershed have a contributing drainage area of approximately 119 square miles at its confluence with Fountain Creek and Monument Creek near downtown Colorado Springs.

Most of the headwaters are part of the Pike National Forest and are dominated by pine and fir forest on very steep slopes consisting of decomposing Pikes Peak granite. Urban development is present in the headwaters, and is likely influencing the watershed. Urban areas include a portion of Woodland Park, and the communities of Crystola, Green Mountain Falls and Cascade. In the middle portion of the watershed, the Pike National Forest continues with pine and fir forest. The stream emerges from a steep canyon immediately upstream of the city of Manitou Springs, where the surrounding geology changes from decomposing granites to the tilted sedimentary layers of the Dakota Hogback. The lower portion of the headwater Fountain Creek watershed contains the city of Manitou Springs and has been developed with interspersed commercial, industrial, and residential areas.

The upstream portion of the creek is a mountain stream with boulders, cobbles, and gravel in a narrow valley. Through the city of Woodland Park, the creek transitions to a wide sand-bed channel. Downstream of the city of Woodland Park, the channel becomes a mountain stream with boulders and natural drops and pools along U.S. Highway 24. The main channel throughout much of this segment has been dramatically altered by the construction of US Highway 24, and exhibits a step-pool morphology characteristic of a stream flowing through a narrow and confined valley/canyon. Downstream of the canyon and through the city of Manitou Springs, the stream has been channelized in several segments, and is diverted underground in many places. Downstream of the city of Manitou Springs, the channel continues to be somewhat entrenched, with occasional meanders down to the confluence with Monument Creek.

Seven major tributary streams contribute to Fountain Creek between its headwaters and the project area in Memorial and Mansions Park within the Town of Manitou Springs. These streams include Catamount Creek, Crystal Creek, Severy Creek, French Creek, Ruxton Creek, and Williams Canyon Creek. Five of these major headwater tributaries have significant reservoirs or other water diversion structures, affecting the natural hydrology of the basin.

The US Geological Service (USGS) Hydrologic Unit of the watershed is 1102000301. The nearest automated stream gauge to the project area is located behind the Safeway west of 31<sup>st</sup> St in Colorado Springs, and is maintained by the USGS and Colorado Springs Utilities (CSU). The location of this gauge is at Latitude 38°51'17", Longitude 104°52'39", in the SE¼SW¼ of Section 3, Township14 S., Range 67 W., on left bank 200 ft upstream from the water diversion for Colorado Springs Utilities, and approximately 2.0 mi downstream from the Memorial and Mansions Park study reach. The watershed area upstream of this gauge is approximately 103 square miles. A 48 year record of flow data is available at this site. For the period of record, peak yearly flows have ranged from a minimum of 43cubic feet per second (cfs) to 2630cfs. The median peak flow during the period of record was 340 cfs.

Extensive hydrologic modeling has been conducted in the watershed using the HEC-HMS model developed by the US Army Corps of Engineers (*Fountain Creek Watershed Preliminary Hydrology Report, URS, 2005*). The Memorial and Mansions Parks Reach is

immediately upstream of the stone bridge at Old Man Trail. A table of the HEC-HMS predictions for above bank-full stage recurrence intervals at the downstream boundary of the study reach is shown in the Table 1. The Memorial and Mansions Park project reach bank full stage discharge is estimated to be approximately 69cfs. Based on the HEC-HMS modeling and cross sectional channel data collected during this assessment, it is estimated that the stream will exceed the carrying capacity of the existing channel and flow into the Park at approximately 4,300 cfs, or somewhat less than a 25 year flood event. At this flow, average velocities in the channel may be expected to reach close to 20 feet per second, exerting in excess of 5 lbs/ft<sup>2</sup> of sheer stress within the channel and adjacent stream banks.

Location	Area (Mi <sup>2</sup> )	Estimated Peak Discharge (cfs)					
		2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr
At 31st St (USGS near Colorado Springs Gauge)	103	330	690	2000	5300	8800	13000
At Old Man Trail	91.1	69	530	1600	4500	7600	11000

Table 1: Storm Event Return Interval Estimates Using HEC-HMS models

### Existing Fish Populations

Fountain Creek contains resident populations of both native and non-native fishes. Three important native species are present in the watershed, including the greenback cutthroat trout (*Oncorhynchus clarki stomias* - federal and state threatened), the Arkansas darter (*Etheostoma cragini*- state threatened) and the flathead chub (*Platygobio gracilis* - a state species of special concern); however none of these species are present in the project reach. Brown trout (*Salmo Trutta*) and brook trout (*Salvelinus fontinalis*) are the most common non-native salmonids in Fountain Creek, and have been observed in the project reach. Additionally, rainbow trout (*Oncorhynchus mykiss*) are occasionally stocked by private individuals, and may or may not remain resident in the watershed. An electro-fishing monitoring site has been established several hundred feet upstream of the project area and is routinely monitored by the Colorado Division of Wildlife and the USGS. During the most recent sampling in 2005, 42 adult brown trout were captured within the station.



Photo 1: Pursuing brown trout in Fountain Creek, Manitou Springs, CO.

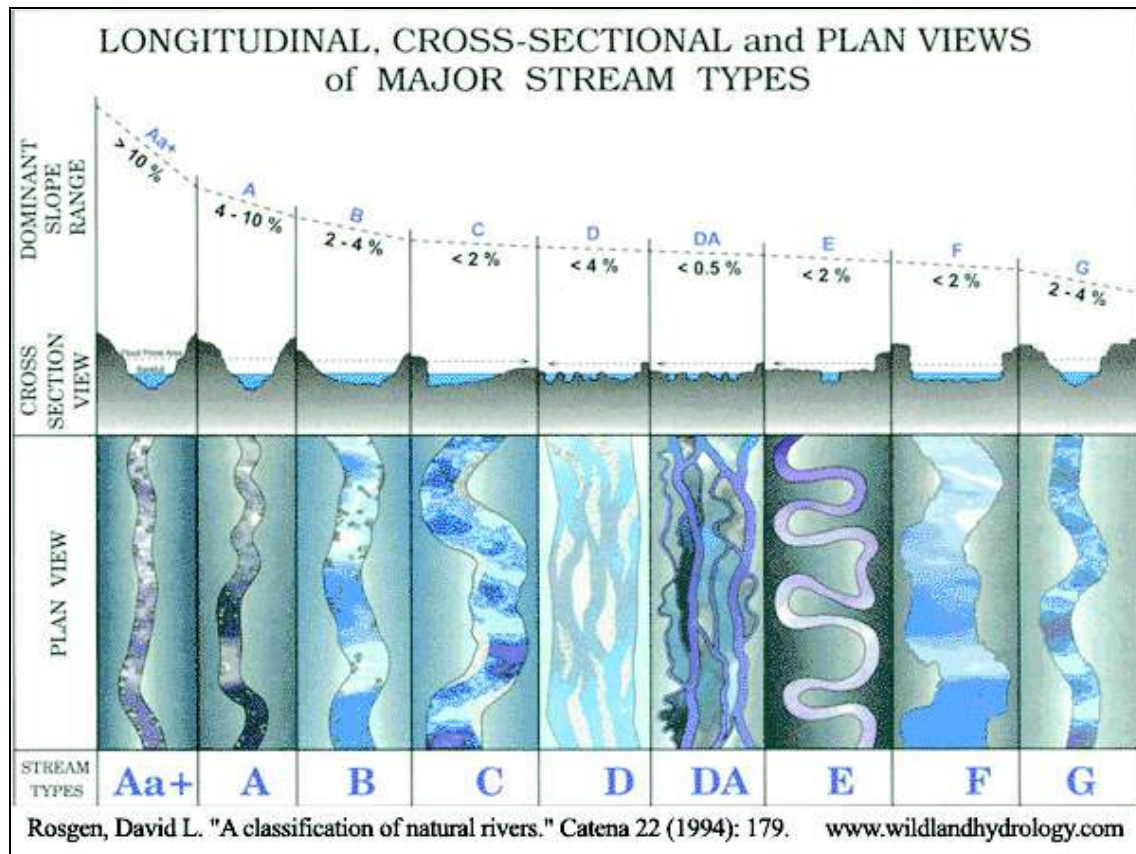


## Stream Channel and Habitat Assessment Methods

For the purposes of this assessment, Fountain Creek through Manitou Springs was delineated into distinct reaches, or segments, based on valley type, channel morphology, perennial vs. intermittent flows, and administrative or physical boundaries. Reaches were numbered consecutively, beginning at the furthestmost downstream ranch boundary, and continuing upstream to the headwaters. A total of 13 reaches were identified within the city limits. The Memorial and Mansions Park study reach is designated as Manitou Springs Fountain Creek Reach 7.

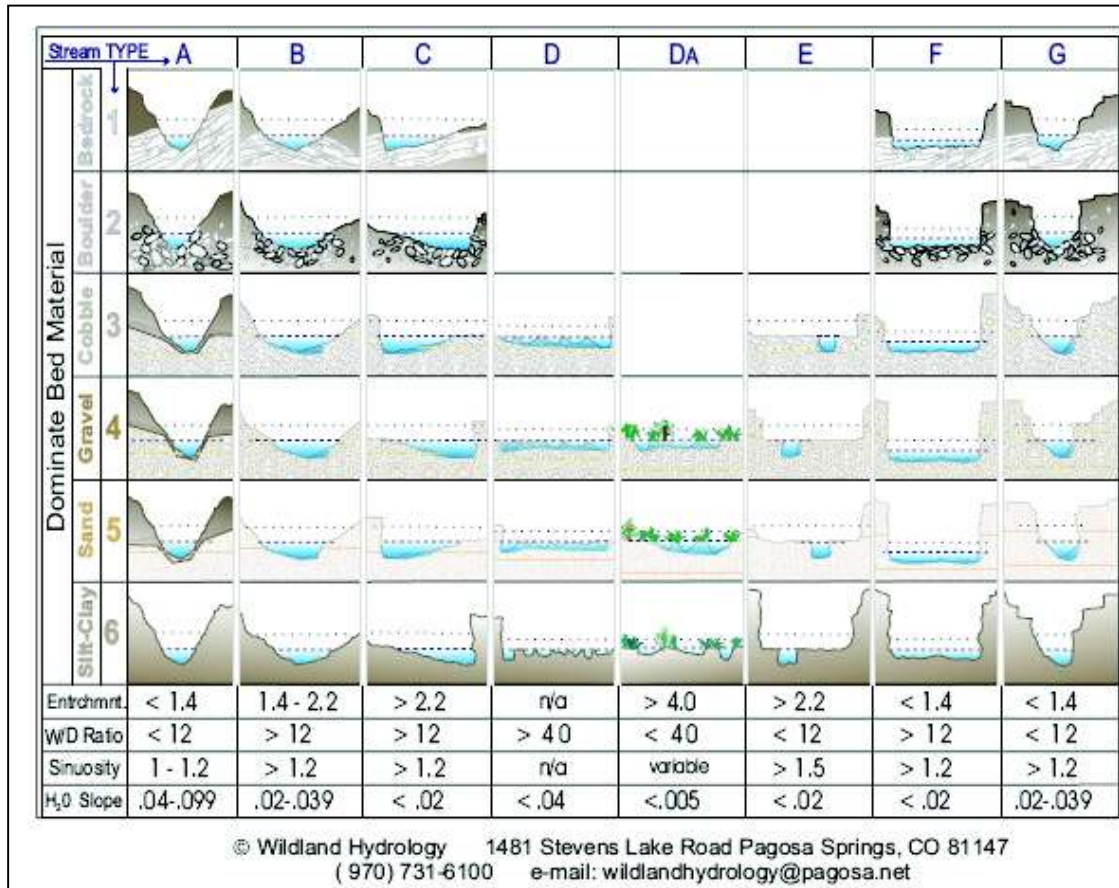
## Rosgen Stream Classification System

Stream reaches are classified using the Rosgen Stream Classification System (D.L. Rosgen, CATENA, 1994). The Rosgen classification system groups streams by similar channel geomorphology, gradient, sinuosity and function. The classification system is stratified into three progressive levels, based on channel form, dominant substrate, and gradient. A graphic depiction of the Level 1 classification is shown in the diagram below.

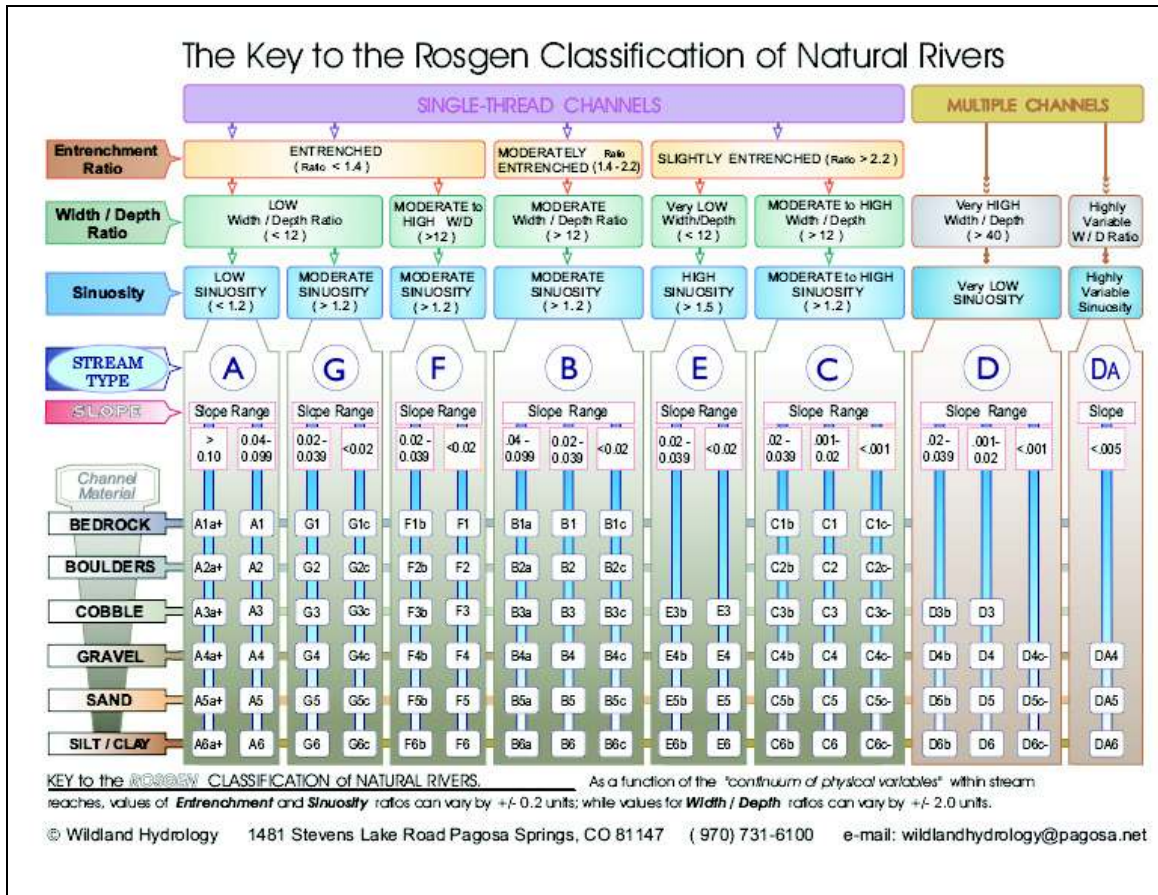


Generally, A type channels are typically found near the headwaters of mountain streams. Lower gradient B channels are characteristic of streams flowing through alluvial plains and broad mountain valleys below the headwaters. C and E channels tend to be found in lower elevation reaches with broad floodplains and low gradients. Each of these channel type supports different assemblages of aquatic habitats, and each can be important in

providing habitat complexity for trout. F and G channels are typically found in areas that have been subjected to some disturbance, such as a flood or significant down-cutting of the stream channel. Frequently, in recovering F type channels, a new C channel will begin to form in the flat bottom of the F channel, establishing a new floodplain at a lower elevation.



The Level 2 classification stratifies dominant substrate composition, and ranges from 1, bedrock or native bed material, to 6, which represents fine particles of less than 1/4" diameter. A diagram of the Level 2 classification is shown on the following page. Level 3 of the Rosgen system includes more detailed gradient and sinuosity values. For example, a Rosgen A3a channel would be a steep (<10%), deeply entrenched, and confined channel that exhibits low width/depth ratios and low sinuosity. Channel materials are typically unconsolidated, non-cohesive materials, dominated by cobbles, but also containing some boulders, gravel and sand. The A3a type is generally found in landforms associated with slump/earth-flow and debris torrent erosional processes, and would likely exhibit fluvial entrainments, mass wasting of steep adjacent slopes and debris scour. A detailed diagram of the Level 3 Rosgen classification system is shown below. The Rosgen classification system has been widely adopted by water professionals throughout the west, and is a useful tool for evaluation and comparative analysis of similar stream channels and habitat conditions.



### Stream Channel Morphology:

For the purposes of the stream channel morphology study, seven cross-sections were established in representative channel types, and numbered consecutively beginning at the downstream boundary of the study reach and continuing upstream. Cross-sections were located in order to validate channel type classification, bank full elevation estimates in the different channel habitat unit types (pool, riffle and glide), and to document existing condition and flow capacity of the channel. All directional references to stream banks and cross-sectional head pins for the channel geometry study are from a hydrologist's perspective, with left and right banks determined looking downstream along the channel.

A longitudinal profile (LP) of the stream channel was surveyed for the study reach in February, 2009. Stream flow was measured at cross-section #3, using a Marsh-McBirney FlowMate 2000 flow meter, and was calculated to be 5 cfs. The stream within the project reach was delineated by channel unit type (pool, riffle, and glide), with channel thalweg depth, water surface elevation, and bank-full elevation being surveyed at each transition between channel units. Additional, intermediate measurements were collected in areas where existing stream structures or other features of interest were present. Detailed plots of the longitudinal profile can be found in the Appendix to this document.

The longitudinal profile is typical of Fountain Creek within the City of Manitou Springs; characterized by moderate channel, water surface, and bank full gradient; with moderate



to significant entrenchment, and pool frequency consistent with “B” and “G” channels. The average slope of the channel, water surface and bank full elevation throughout the profile in Reach 7 was 1.7%. Riffle slopes ranged from 0.2% to 6%, with several drop features exceeding 20%. Stream channel sinuosity was low (channel length / valley length = 1.18) in Reach 7.

Plots of each of the seven cross-sections in the project reach can be found in the Appendix. The channel profile in each of the cross-sections exhibits moderate to severe channel entrenchment (flood prone channel width/ bank full channel width) throughout the reach. Entrenchment ratios of less than 1.75 were observed at all of the cross-sections. Width/depth ratios ranged from 24 to < 5.5, which is consistent with the somewhat confined and incised nature of the channel throughout the reach. W/D ratios were found to be consistent with what would be expected to occur in disturbed “G” and “B” channels.

The general reach substrate was calculated using a Z-Walk pebble count (Bevenger, 1997) and the results are shown in Table 1. A slightly tri-modal distribution of smaller particles (fines), large gravel/small cobble, and small boulder is apparent in the pebble count data (Chart 1). We have found this distribution to be relatively consistent throughout all of the Manitou Springs reaches on Fountain Creek, and suggests that sediment inputs to the stream may exceed the capacity of the stream to move the material. The D50 (mean) particle size is estimated to be approximately 8mm, and the D84 particle size is estimated to be 100 mm. Particle size ran from very fine sand to large boulders up to 1 meter along the medial axis.

<b>Z-Walk Pebble Count</b>		Class		Total	% of	Cumulative
Metric - mm	Inches	Name	Number	Total		%
<.066		Silt			0.00%	0.00%
.066 -.125		Very Fine	8		2.70%	2.70%
.125-.25		Fine	23		7.70%	10.30%
.25-.50		Medium	21		7.00%	17.30%
.50-1.0		Coarse	9		3.00%	20.30%
1.0-2.0		Very Coarse	21		7.00%	27.30%
2.0-4.0		Very Fine	31		10.30%	37.70%
4.0-8.0		Fine	42		14.00%	51.70%
8.0-16	.08-.6	Medium	35		11.70%	63.30%
16-32	.6-1.3	Coarse	18		6.00%	69.30%
32-64	1.3-2.5	Very Coarse	19		6.30%	75.70%
64-128	2.5-5.0	Small	24		8.00%	83.70%
128-256	10-May	Large	19		6.30%	90.00%
256-512	20-Oct	Small	18		6.00%	96.00%
512-1024	20-40	Medium	12		4.00%	100.00%
1024-2048	40-80	Large			0.00%	100.00%
2048-4096	80-160	Very Large			0.00%	100.00%

Table 1 - Results of the Z-Walk pebble count, showing distributions of substrate size classes in Reach 7 on Fountain Creek.

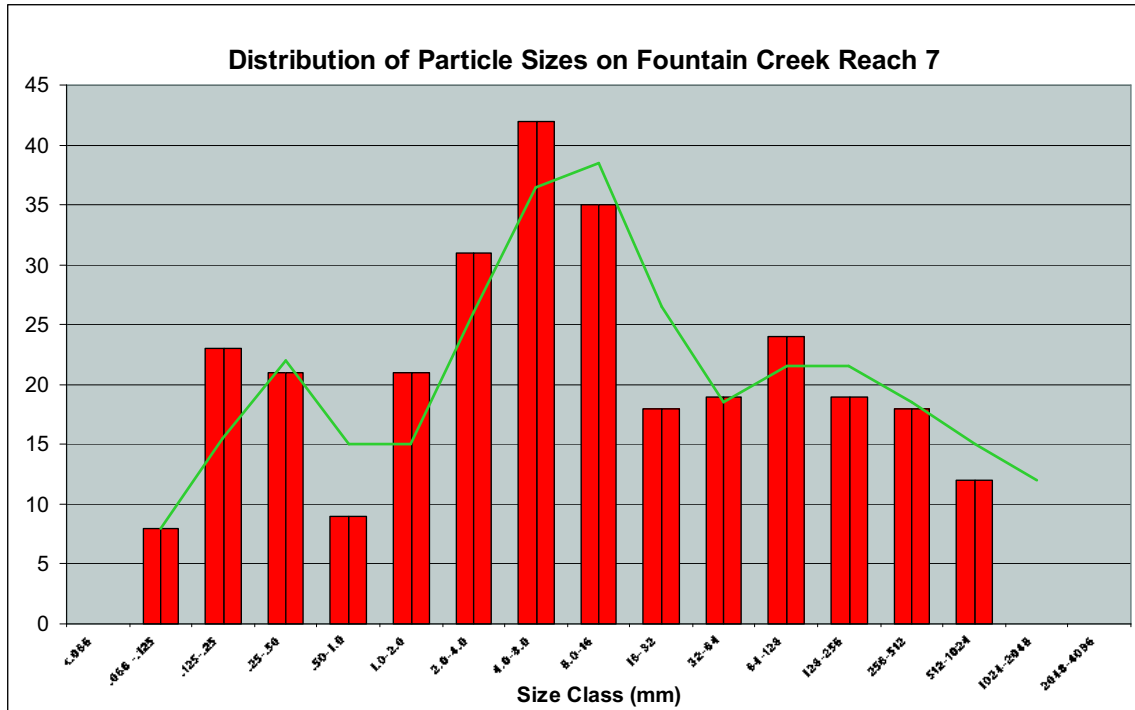


Chart 1 - Distribution of sand, gravel, cobbles and boulder in Reach 7 on Fountain Creek.

Based on the reach longitudinal profile survey, the channel cross-section analysis, and stream substrate composition throughout the reach, the channel in the project reach was classified as a “B4c” type from the bridge at Old Man Trail upstream to the bridge at El Paso Avenue. Upstream of this point, the channel is seriously confined by buildings adjacent to and overhanging the stream, and exhibits characteristics of a G4c channel. Near the upstream boundary of the reach, adjacent to the Stage Coach Inn, the channel returns to a “B4c” form. The stream appears to be vertically stable within the confined channel, however, there appear to be high shear forces effecting retaining walls and building foundations within the “G” channel segment of the reach. There may be a risk of failure of these features in a significant flood event, which may have serious consequences for buildings and infrastructure downstream, and may likely have a negative effect on the quantity and quality of useable habitat for resident trout.



Photo 2: Cobble riffle in a B Channel within Reach 7 of Fountain Creek



**Aquatic and Riparian Habitat Assessment Protocols:**

The aquatic assessment is intended to characterize existing habitat conditions and evaluate current management and restoration potential. The stream reach is analyzed using a basin-wide stream habitat survey protocol developed by the US Forest Service and Colorado Division of Wildlife for smaller streams in the Rocky Mountain Region (Winters and Gallagher, 1997). This protocol is a modified basin-scale aquatic habitat inventory based on the Hankin & Reeves survey method. All meso-habitat types within a delineated reach are measured for multiple attributes, including physical dimension, morphic form, bank condition and composition, substrate class, and cover for salmonids. The advantage of the Winters protocol is that it is a repeatable method, and therefore can be used to quantify changes in habitat resulting from management, habitat enhancement, or natural events. A copy of the Winters Protocol is provided as a separate document under this contract. For the purposes of the stream and riparian habitat study, all directional references are from a fisheries biologist's perspective, with left and right banks determined looking upstream along the channel.

**Aquatic Habitat Survey Results:**

The project reach for this study is located in on the central part of Manitou Springs and is delineated as Reach 7 (Map 1). Reach 7 on Fountain Creek encompasses all of Memorial and Mansions Park, beginning at the stone bridge where Old Man Trail crosses Fountain Creek. The reach continues upstream 1,545 feet to the concrete bridge at the Wichita Parking Lot.

A rapid assessment of aquatic habitat was undertaken within the reach, and a detailed stream habitat inventory was conducted in February, 2009 within the project area. Discharge was measured during the survey at a point approximately in the middle of the project area using a Marsh-McBirney Flow-Mate 2000 flow meter, and was calculated to be 5 cubic feet per second, which is within the estimated base flow range for the stream.



Photo 3: Concrete block drop structure - Mansions Park behind City Hall.

### Reach 7:

Reach 7 has, for the most part, been dramatically altered through channelization and encroachment of urban development. The reach is characterized by a moderately incised channel through relatively stable depositional material composed mostly of larger gravel and small cobble. The stream exhibits a very narrow valley bottom with minimal riparian green-line, low sinuosity and moderate (2%) gradient. Habitat for trout appears to be quite limited due to the very high sediment supply available from both upslope and channel derived sources. Two large log drop structures exist in the reach; one immediately adjacent to City Hall (Photo #3), and another near the upstream boundary. These structures may represent barriers to fish passage through the reach. Initial reconnaissance indicates that Reach 7 exhibits generally poor quality aquatic habitat. Sedimentation from local erosion sources, as well as other sources upstream, are negatively impacting aquatic habitat within the reach.

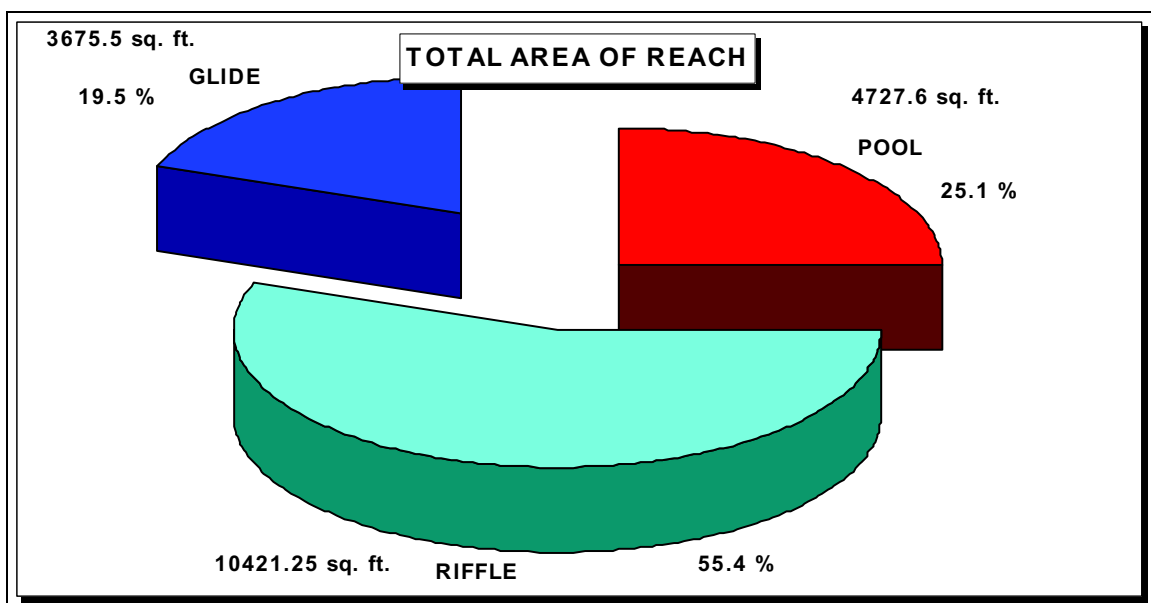


Chart 2 - Distribution of pool, riffle and glide habitats in Reach 7 of Fountain Creek.

There were 56 individual meso-habitats measured in the reach (20 pools, 24 riffles and 12 glides), along a length of 1,523 feet of stream, and comprising a total wetted area of 18,824ft<sup>2</sup>. The total area of the reach consisted of 55% riffles and 25% pools, with the remaining 20% consisting of glide habitat (Chart 2). The average wetted width of the stream was 12.2 feet throughout the reach. Much of the reach is confined by retaining walls forming either side of the stream. Where vegetated stream banks exist, bank stability throughout much these areas was relatively poor, with alder, willow and cottonwood comprising most of the riparian vegetation. Several areas of bank degradation and instability are found within the reach. The causes of stream bank instability in these areas include bank failure from shear at high flows and heavy recreational use, particularly on the north, right stream bank adjacent to Memorial park. There were 320 feet of actively eroding stream banks contributing sediment directly into the stream. This accounted for slightly more than 10% of the total length of banks in the study reach.



Photo 4: Lower half of Memorial and Mansions Park project reach, looking upstream.

Lower gradient cobble and gravel dominated riffles exhibiting little or no pocket water habitat were the most common habitat type in terms wetted area, accounting for 34% of the total reach area (Chart 3). Low gradient riffles can provide good spawning habitat, but are somewhat limited in terms of cover from high flows and predators. Higher gradient, boulder and cobble dominated riffles were the next most common riffle habitat form, accounting for 13% of the wetted area of the reach. Some pocket water habitat was present in these riffles, but generally was limited and relatively poor quality. Reach 7 exhibits many of the same excess sediment deposition problems found in other reaches in Manitou Springs.

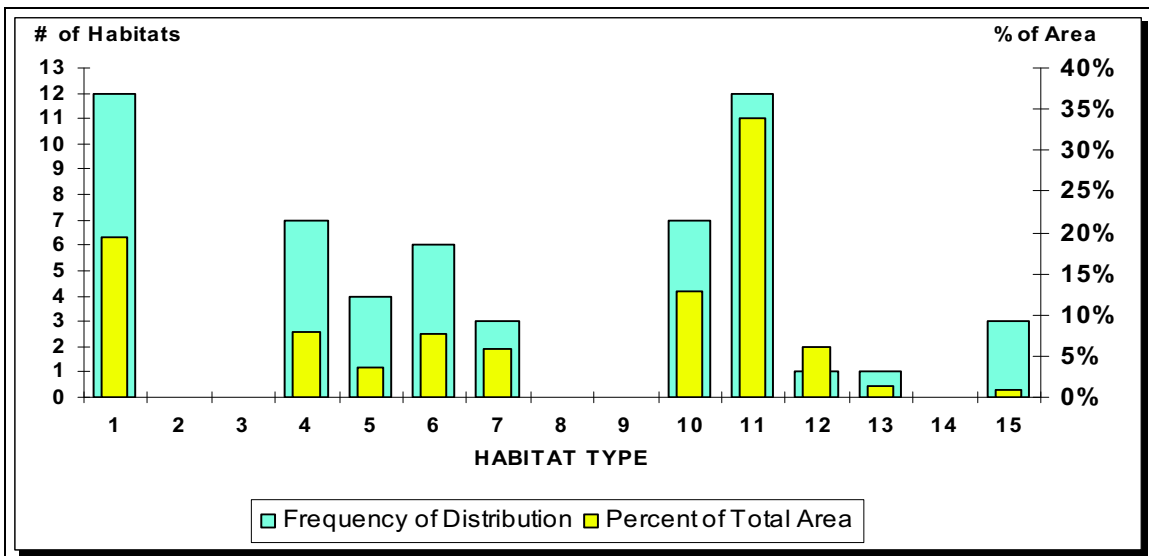


Chart 3 - Distribution of meso-habitat types as a percentage of # of habitats and as a percentage of wetted perimeter of Reach 7 on Fountain Creek.



For the most part, sediment impacts to Reach 7 are likely occurring from sources upstream, and this has reduced the quality and utility of the pocket water micro habitats. Overall, very little cover for trout was observed in these riffles, amounting to less than 0.5% (55 ft<sup>2</sup>) of the total wetted area of these habitat types. The average width of all the riffles observed in the reach was 12 feet.



Photo 5: Upper barrier adjacent to Lover's Lane – Fountain Creek Reach 7.

Pool habitat is relatively limited in the reach, with trench pools being the most abundant, comprising 8% of the total wetted area of the reach (Chart 3). The trench pools were mostly associated with constrictions in the stream channel created by cottonwood and other tree root systems, boulders and failed concrete retaining walls along the stream bank. Lateral scour pools were the next most dominant pool form, and were mostly associated with root wads and retaining walls causing a downward scour along the outside of meander bends. Dam pools and plunge pools were also observed in the reach, accounting for somewhat less wetted area than the trench pools. The plunge pools were principally associated with artificial drop structures that may represent barriers to fish migration through the reach. One plunge pool consists of a 2 ft drop in water surface elevation through the structure.

Dam pools and plunge pools comprised 6% and 4% of the total wetted area of the reach. All of the pools exhibited some degree of in-filling of sediment, mostly consisting of smaller particles of decomposed granite. The average pool depth in Reach 7 was 0.96 feet. Residual pool depth (RPD) in Reach 7 was found to range from 0.4 to 1.4 feet, with an average of 0.8 foot throughout the reach. RPD in Reach 7 is considered to be very poor, and may limit adequate over-wintering habitat for salmonids and other native species in this segment of Fountain Creek. Cover for trout accounted for slightly less than 7% of the total wetted area of the pools, which is fair to poor for a stream of this size. The average wetted width of all pool types found within the reach was 11 feet.



Photo 6: Over-wide glide habitat resulting from an un-authorized hand made dam structure along the Memorial Park segment of Reach 7.

A considerable number of glides were observed, comprising 20% of the reach. Glide habitat appeared to be the result of excessive sediment inputs upstream. Most of the glide habitats observed appeared to be former pools that had been completely in-filled with gravel and smaller diameter materials. Cover for trout was extremely limited in these habitats, which are characterized by laminar flow profiles and tend to provide little velocity shelter or protection from predators. Aggradation of sediment in the glides is resulting in a gradual over-widening of the bank full channel in these meso habitat forms. The average width of the glides observed in Reach 7 was 13.5 feet.

All forms of cover for adult trout accounted for only 2% of Reach 7 (Chart 4). Available cover was significantly less than that observed in Reach 4 and Reach 11, and is likely a important contributing limiting factor to the health of the fishery. Creating additional cover will be an important component in the Habitat Enhancement Plan. Instream object cover (Cover Type 2 - >1' deep) was the dominant type observed in the reach, but was limited mostly to the pool habitats. Pool cover (Cover Type 5 - >1.5' deep) was very limited in the reach, and comprised only 1.7% of the wetted area of the pools and 0.5% of the total reach area. Pool cover is an important indicator for determining the available over-wintering capacity of the stream reach, and appeared to be severely limited in this reach.



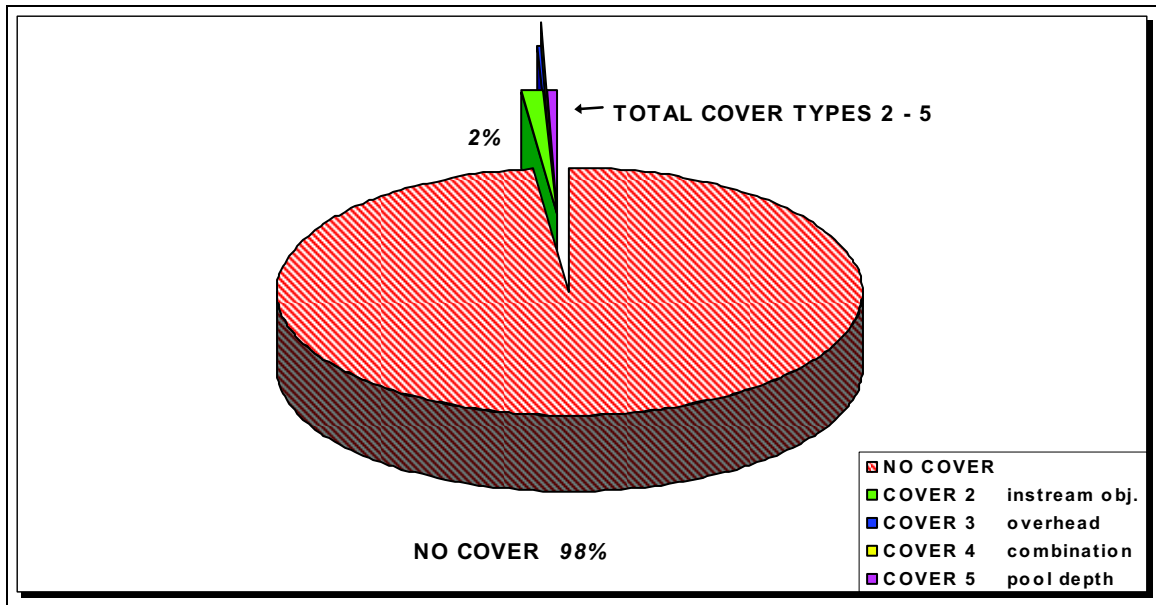


Chart 4 - Percentage of cover for trout to the total wetted perimeter Reach 7 on Fountain Creek.

Combination and overhead cover were the least abundant cover types, due to the lack of velocity shelter along the stream bank and limited large wood in the channel. Instream and overhead cover could be enhanced in the riffle habitats by adding structure and velocity shelters along the stream banks with strategically placed boulders and large wood. Pool cover may be increased by improving scour in existing pools as well as creating new pool habitats. Combination cover may be improved throughout the reach through stabilizing and revegetating the eroding stream banks using large wood toe-slope stabilization techniques.

Stream bank stability was generally poor in the lower part of the reach, within Memorial Park, and was dependant on vegetation composition and degree of recreation use along any particular stream bank. Generally well vegetated stream banks were found on the side of the stream opposite of Memorial Park, with the notable

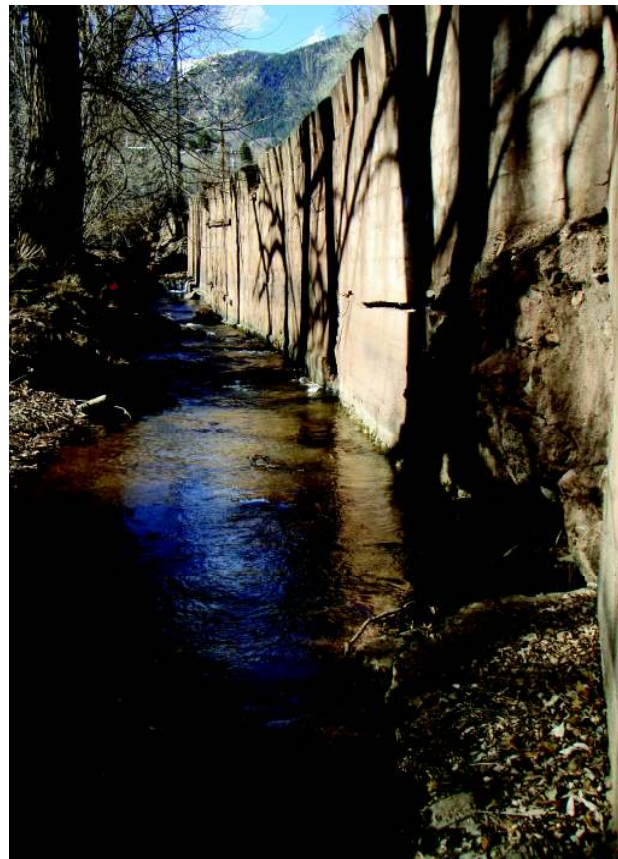


Photo 7: Unusual combination cover formed by failing concrete retaining wall footings - Lover's Lane retaining wall - Reach 7.

exception of one area immediately downstream of the stone bridge at El Paso Boulevard. Areas of actively eroding stream banks were observed, particularly along the side of the stream adjacent to Memorial Park, and underneath the City Hall building, where stream bank erosion has completely exposed and is beginning to undermine the building foundation. Concrete retaining walls throughout the reach are in varying degrees of condition, ranging from stable and secure, to highly unstable and at risk of failure. Of particular concern are the building foundation walls of the Pikes Peak Inn, on the left stream bank at 0+ 898 ft. along the longitudinal axis of the reach, and extending upstream to 0+993 ft. Several segments of this foundation wall have cracked, collapsed, or eroded away, and there may be a serious breach/flood risk along this segment, even during a relatively small flood event on the main stem of Fountain Creek.

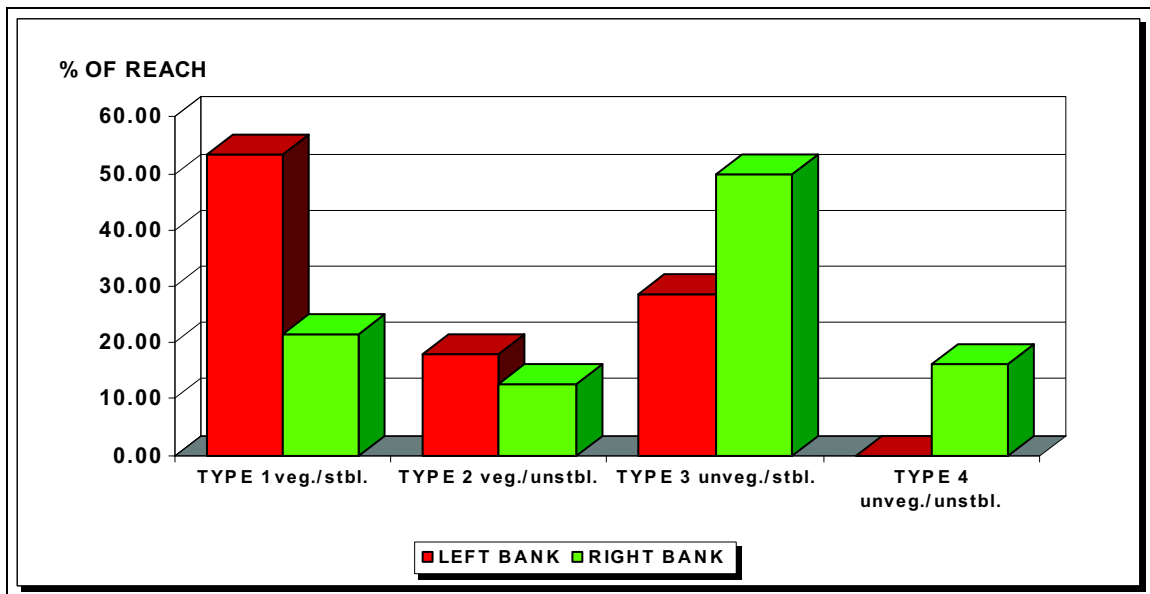


Chart 5 - Percentage of stable banks to unstable banks in Reach 7 on Fountain Creek.

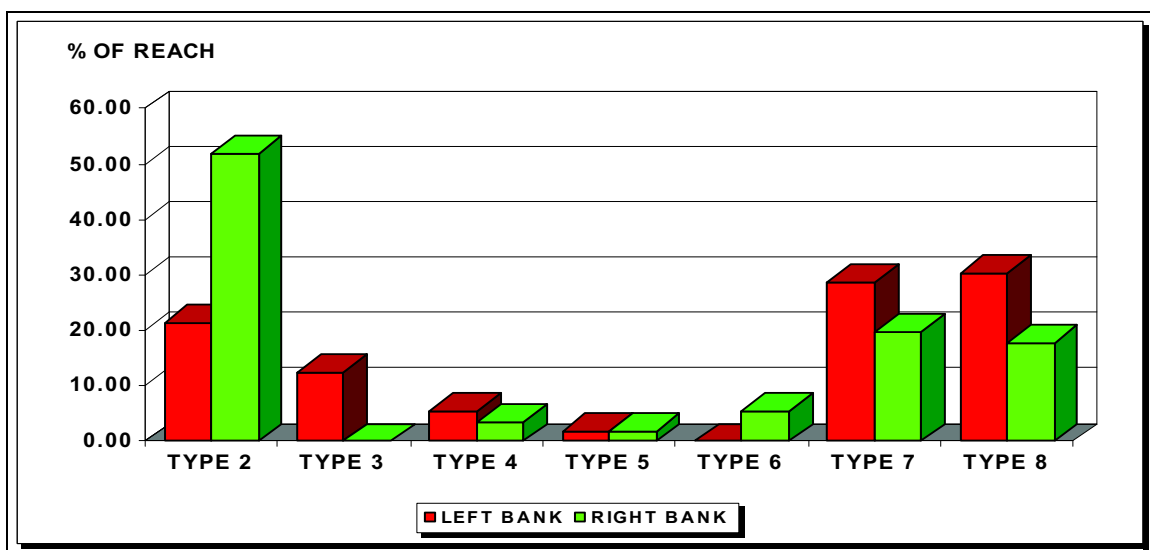


Chart 6 - Percentage of bank rock content sizes in Reach 7 on Fountain Creek.

Eighty-two percent of the left bank and 71% of the right bank were found to be stable. The remaining 18% of the left bank and 29% of the right bank were found to be generally unstable and at risk of failure due to high flow shear forces on the banks (Chart 5). Bank rock content in the reach is shown in Chart 6, and consisted principally of gravel and smaller fragments (Type 7 & 8). Most of the larger BRC consisted of concrete retaining walls, which were classified as Type 2 for the purposes of this survey. Smaller fragments of less than 1/8" were the most dominant type, indicating that the stream banks are susceptible to erosion due to high flows.

Aquatic habitat conditions throughout Reach 7 were generally very poor. Limiting factors to the fishery appear to be poor scour and excessive sedimentation, due, in part, to inputs from sources upstream. These factors result in poor quality pool habitat, and limited in-channel object cover in both the low gradient and pocket water riffles. Several problem areas were identified during the course of the inventory that should be addressed in order to alleviate potential worsening problems and loss of habitat, as well as to help the river achieve its full potential as a cold water fishery.



Photo 8: Two trench pools (Pool #15 and Pool #16) formed by a large cottonwood tree forming a constriction in the channel near the upstream boundary of Reach 7. Both of these pools exhibited efficient scour of sediment, acceptable residual pool depths, and maximum pool depth in excess of 1.5 feet.



### **Aquatic Habitat Enhancement Plan for Fountain Creek - Reach 7.**

Several segments of Reach 7 may benefit from efforts to restore of the channel, stream banks, and associated aquatic and riparian habitats. Restoration of the reach is limited, however, by several factors that may constrain any effort to return the stream to its natural hydrologic function. Limits to restoration include the inability to significantly change the dimension, pattern or profile of the channel through the reach, due to urban development along the stream banks, and the existence of critical infrastructure adjacent to the creek. The assessment has identified several segments where strategic improvements may enhance the stream corridor, both in terms of hydrologic and habitat function, as well as improving esthetic values within the reach.

For the purposes of the restoration plan, the Reach 7 is divided into four distinct sub-reaches, based on feasibility of restoration and priority of treatments. Sub-Reach 7a includes all of Memorial Park, and is the highest priority segment for treatment. Sub-Reach 7b, is the next priority, and includes the stream within Mansions Park, upstream to the foot-bridge at 0+861 ft., leading from the park to the police station. From the foot-bridge to the possible migration barrier at 0+1,221 ft., the stream channel is inaccessible to heavy equipment, and is designated Sub-Reach 7c. This segment will be the lowest priority for treatment, which will consist of mostly manual labor and hand treatments by volunteers. The final segment, Sub-Reach 7d, extends from the barrier at 0+1,221 ft upstream to the end of the reach. This segment currently contains some of the best quality pools in the reach, and requires only a few treatments to address bank stability and pocket water cover limits within the riffle habitats, and will rank as the third priority for treatment within the reach.

Natural river restoration techniques will be utilized to enhance and restore Reach 7 on Fountain Creek, creating new holding areas and cover for trout within the stream. Pool scour will be enhanced by adjusting boulders to optimize the river's capacity to move sediment. Enhancing pool scour should increase average pool depth and residual pool depth in the channel, providing additional cover and over-wintering capacity for trout, and are expected to be self-maintaining. Pool habitat will be increased by constructing boulder cross vanes to scour existing

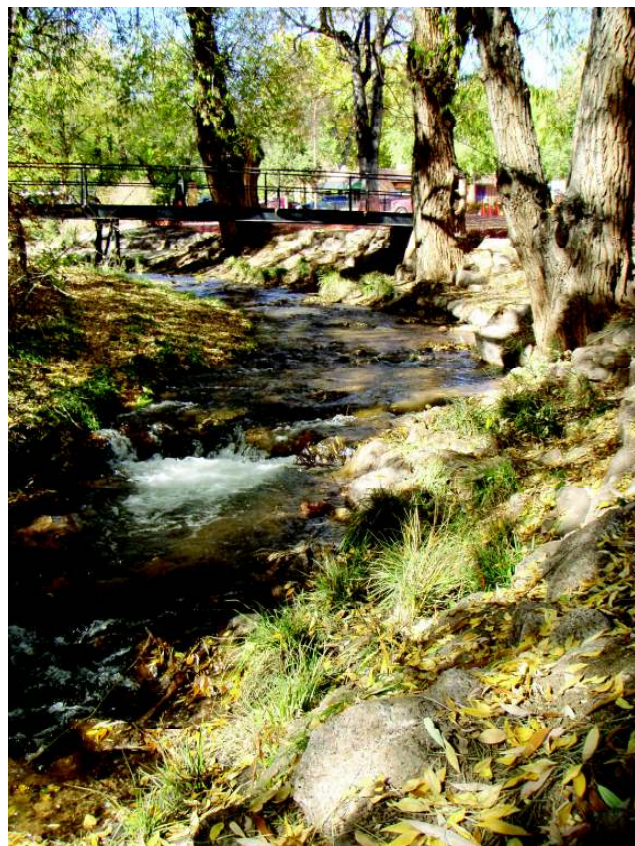
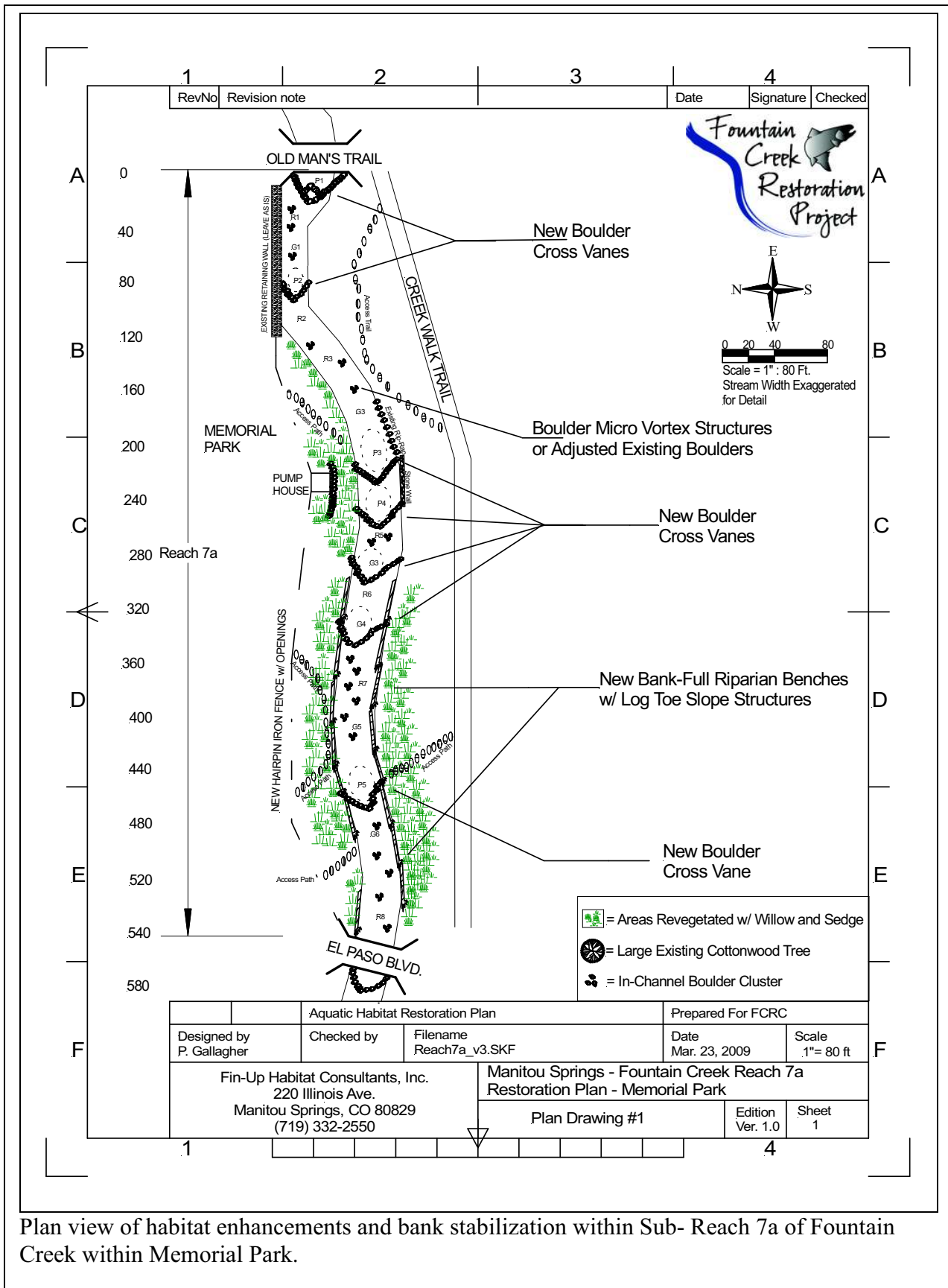


Photo 9: Restored stream bank and cross—vane. Soda Springs Park Reach 11 on Fountain Creek.



Plan view of habitat enhancements and bank stabilization within Sub- Reach 7a of Fountain Creek within Memorial Park.



glide/run features in the channel. Restoration treatments will include bank stabilization and re-vegetation, as well as in-channel stream habitat enhancement within segments of Reach 7 that are accessible to equipment and volunteers. The following section describes the treatments recommended for each segment. A site plan showing the locations of the proposed enhancements in Sub-Reach 7a can be found to the left. Site plans for each sub-reach can be also be found in the Appendix. Please note that stream width is exaggerated in these site plans in order to detail in-channel habitat features.

### **Restoration Plan for Sub-Reach 7a – Memorial Park**

A boulder cross-vane will be installed at the downstream boundary of the reach, enhancing the existing pool under the bridge at Old Man Trail. This cross vane will also provide enhanced vertical stability in the stream channel at this point, as well as protect the foundations of the historic stone bridge. Pocket water cover will be increased within Riffle 1 and Glide 1, using small rock cluster vortex structures. Pool 2 will be enhanced and expanded downstream into Glide 1 by constructing a boulder cross-vane near the top of this habitat, improving scour through the feature. Pocket water cover is currently adequate in Riffle 2, and will be increased in Riffle 3 by adjusting existing boulders in the riffle to provide better scour pockets downstream of these features. A cross-vane will be installed at Pool 3 to improve depth and extend the length of this habitat, and to reduce shear on the historic stone wall on the left side of the stream immediately upstream of this structure. Another cross-vane will be installed upstream at Pool 4 to further enhance this pool, as well as protect the pump-house perforated pipe buried on the right bank of the stream. This pipe is used to draw water from the stream for the purposes of irrigation of the park facilities, and currently requires continual maintenance due to being plugged up by fine sediment. A cross-vane will also be installed at the upstream limit of Glide 4, to covert this habitat to a functioning pool.

Approximately 100 feet of the right stream bank, from the end of the retaining wall at Riffle 2 to Riffle 5 will be re-vegetated using volunteers from the Rocky Mountain Field Institute. Several stone retaining walls will need to be constructed in the area adjacent to the pump house, in order to provide a stable terrace for vegetation to take hold. The existing 30 ft segment of boulder rip-rap on



Photo 10: Glide 1, Pool 2, and Riffle 2 on Reach 7, looking upstream.

the left bank of Pool 3 will be re-aligned in order to provide velocity shelter for trout as well as bank armoring and protection from shear. The existing creek access trail on the left bank will be repaired, with stone steps leading down to Pool 3. Additionally, a new stone stairway will be constructed on the right bank leading to the stream, immediately downstream of the pump house.



Photo 11: Over-wide segment of Fountain Creek in Memorial Park, looking downstream.

Upstream of the pump-house, the stream begins to exhibit excessive over-widening, due to sedimentation, bank damage from heavy recreational use, and the construction of an un-authorized dam perpendicular to the direction of flow that has resulted in bank failure and lateral migration of the channel. This hand constructed dam will be removed from the channel, and a large boulder cross-vane will be installed at Pool 5 to significantly improve the scour and depth of the pool and downstream glide habitat. The stream channel throughout this segment will be narrowed and re-defined using large wood toe-slope structures and bank-full riparian benches on both sides of the stream to reduce the width/depth ratio of the channel and improve sediment transport within the segment. The target bank-full width of the new channel will be 22 feet. Additional sinuosity will be built into this segment by building a slight meander into the newly defined channel. A total of 300 feet of these treatments will be necessary, split approximately evenly on each side of the channel. Narrowing the channel and improving sediment transport through this segment will allow us to increase and improve pocket water habitats within the riffles by adjusting the elevations and facet slopes of existing boulders in the riffles, and by adding additional boulder micro-vortex structures in appropriate locations throughout these riffle habitats. Up to twelve of these features may be added to Riffles 7 & 8.

Stream banks in this segment exhibit the same instability and lack of vegetation as the banks in Soda Springs Park (Reach 11), and similar treatments will be used to restore and revegetate the banks. In addition to the log/boulder toe-slope treatments to narrow and define the meander in this segment, several low stone walls/terraces will be constructed to alter and vary the slope of the bare banks leading to the stream and allow for re-vegetation with native riparian and upland plant species. All stream bank re-vegetation treatments will be coordinated with the Rocky Mountain Field Institute.



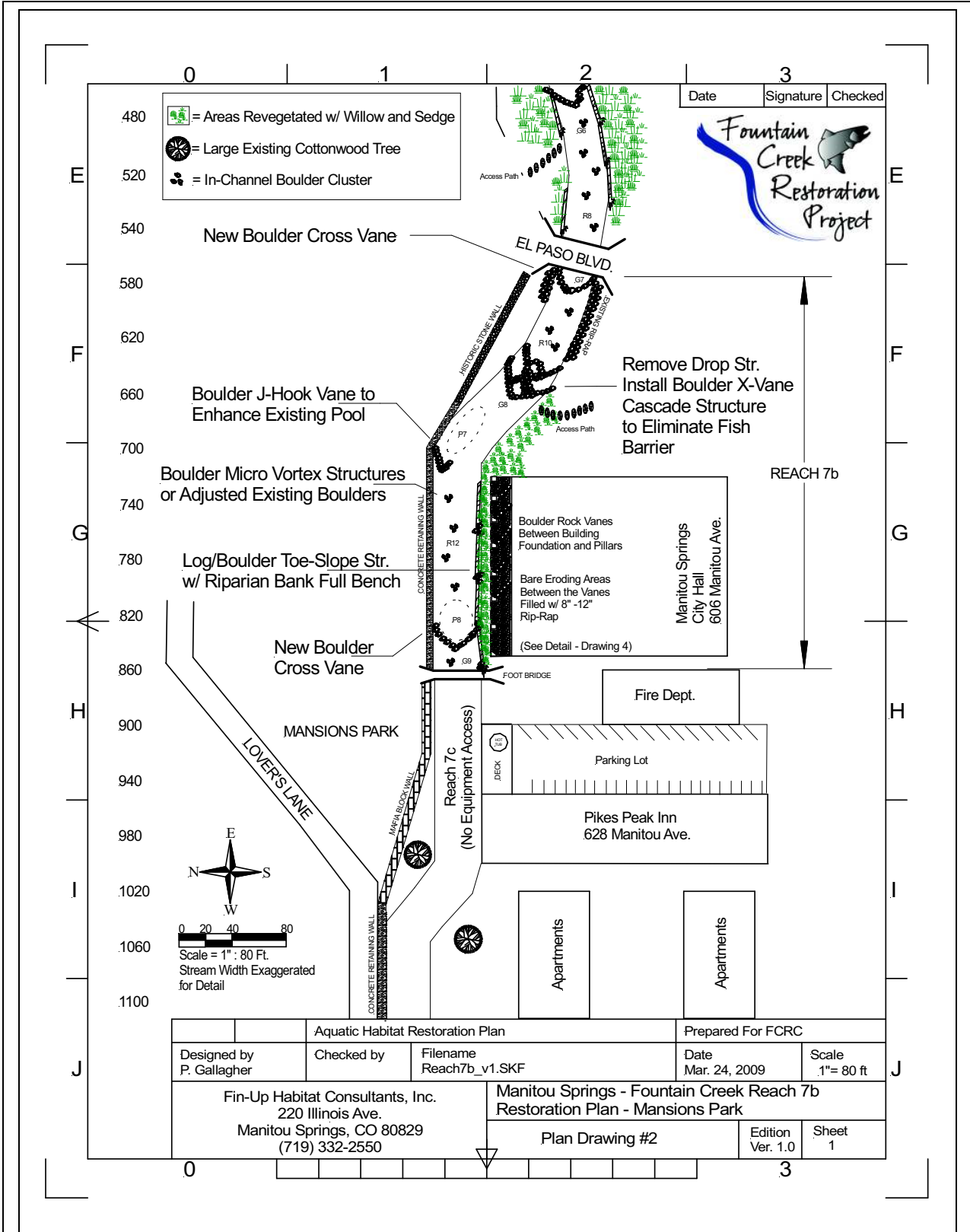


Photo 12: Volunteers constructing terrace walls for revegetation of stream banks. Similar techniques will be used in Sub Reach 7a to stabilize stream banks.

At least one access path will be constructed from the Creek Walk trail on the south side of the stream down to the vicinity of Pool 5. Additionally, two access paths will be constructed on the north side of the stream to allow Memorial Park users to access the creek in this area. The areas immediately adjacent to the access paths will be strategically re-vegetated using woody plants that will discourage wandering off of these designed routes. To protect the stream bank restoration efforts, we strongly recommend the installation of a permanent iron hair-pin fence, with openings at each of the designated access paths, similar to the fence installed in Soda Springs Park as part of the stream restoration project in 2008. The Memorial Park fence would extend 450 feet along the north side of the creek, from the retaining wall at Riffle 2 upstream to the stone bridge at El Paso Boulevard.



Photo 13: Iron hair-pin fence w/ path openings in Soda Springs Park (Reach 11)



Plan view of habitat enhancements and bank stabilization within Sub- Reach 7b of Fountain Creek within Mansions Park.



## Restoration Plan for Sub-Reach 7b – Mansions Park

A boulder cross-vane will be installed immediately upstream of the stone bridge at El Paso Boulevard. This cross vane will provide vertical stability in the stream channel and provide some protection the foundations of the historic stone bridge, while providing some additional pool habitat and fish viewing opportunities from the bridge. Pocket water cover will be increased within Riffle 9 & 10 by adjusting the elevation and aspect of existing boulders in these habitats. The center of the concrete “mafia block” drop structure and barrier at Riffle 11 will be removed, and replaced by a series of two boulder cross-vanes extending upstream into Glide 8 to create a step-pool cascade connecting the channel elevations between Pool 6 and Pool 7. The sections of the concrete drop structure that are embedded into the stream banks will be left in place, to provide bank stability at this point, but will be covered with top-soil and re-vegetated to camouflage these features. Pool 7 will be enhanced and expanded by constructing a boulder J-Hook vane near the top of this habitat, improving scour through the feature. A single access path, leading from the City Hall visitors parking area to Pool 7 will be constructed by volunteer crews.

Riffle 12, Pool 8, and Glide 9 are confined by a concrete retaining wall on the north bank, and by the foundation walls of Manitou Springs City Hall on the south. The City Hall building overhangs the creek by 10 feet throughout this segment (see Cross-Section 5). Periodic high flows have begun to undermine a significant section of the building foundation on the north east corner of the building, and if not quickly addressed, could result in undesirable structural changes to the building. A thin line of riparian alder and



Photo 14: Fountain Creek adjacent to City Hall, looking upstream. The eroding foundation can be seen on the left side of the photograph.



willow has become established between the creek and the edge of the building, and we would like to further enhance this protective feature by installing log/boulder toe slope structures and riparian bank full benches along the entire south stream bank adjacent to the building. Behind these bank full bench features, boulder vanes may be installed underneath the building, extending at an angle of no greater than 30 degrees, from the foundation wall upstream to the concrete columns supporting the outer edge of the building. The spaces between these vanes could then be filled with smaller 8" – 12" rip-rap by the volunteer hand crews organized by the Rocky Mountain Field Institute.

The installation of bank full benches along the edge of the City Hall building will slightly reduce the width of the channel throughout this segment, which will, in term, allow us to further enhance in-channel aquatic habitat through this segment. Existing boulders in Riffle 12 will be adjusted to improve pocket scour and velocity shelter. These features, combined with occasional under-cut bank features built into the bank toe slope structures will significantly increase cover and holding areas in this marginal riffle habitat. In addition to the pocket water features, a boulder cross-vane will be installed at Pool 8 to improve depth and scour, and to direct the thalweg away from the building foundations downstream of this point.

### **Restoration Plan for Sub-Reach 7c – Lover's Lane Vicinity**

The segment of Reach 7 on Fountain Creek between Pool 9 at 0+873 feet and Pool 13 at 0+1,197 ft is mostly confined by buildings on the south side of the stream, and a large concrete retaining wall supporting Lover's Lane on the north side of the channel. This segment, in its current configuration, is inaccessible to heavy equipment, and is, for the most part, beyond the scope of restoration described under this project. This segment of Fountain Creek exhibits the most severely confined length of stream channel in the entire three miles of the stream as it flows through Manitou Springs (see Cross-Section #6), and likely represents a significant flood and breach event risk. Compounding this risk is the current condition of the retaining wall on the north side of the stream and the building foundation walls and footings on the south side of the stream at the Pikes Peak Inn, which



Photo 15: Pikes Peak Inn

appear to be in perilous condition, and might fail in a significant flood event, blocking the channel with debris and subsequently causing greater flood damage downstream. We recommend that the City contact the owners of the Pikes Peak Inn, and work with them to repair or remove this wall.

While it is beyond the scope of this assessment to address these significant flood risk issues, there may be some relatively simple measures that could be taken to reduce the risk of catastrophic flood/breach/flood events in this segment. We would recommend that the City consider permanently closing and removing Lover's Lane from a point beginning at west side of Mansions Park on the east and the Wichita Parking lot

on the west. Removing both the road and the retaining wall on the north side of the stream would effectively increase the cross-sectional area of the stream channel through this confined segment, increasing the capacity of the channel to pass flood flows and debris with a lesser risk of debris damming and breaching. Creating a small bank full flood-plain on the north side of the creek at this point would allow for the Creek Walk trail to be constructed on this side of the stream. This strategy also has the advantage of not requiring the removal of any buildings or otherwise affecting private property. While this work is well beyond the scope of the Fountain Creek Restoration Committee and the aquatic habitat projects described herein, this might be a viable project to present to the newly formed Fountain Creek Watershed, Flood Control and Greenway District for assistance in development and funding.

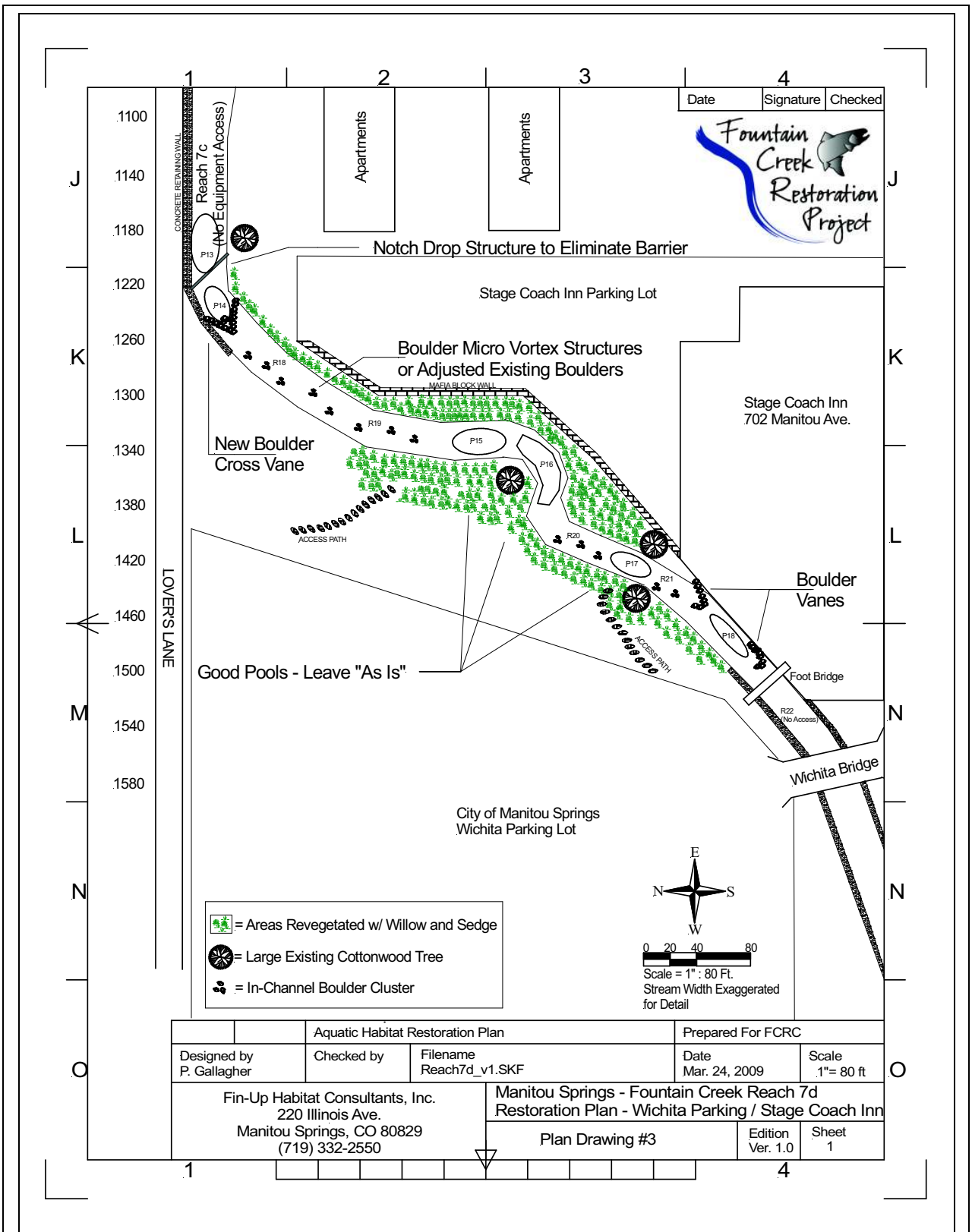


Photos 16 & 17: Failing retaining walls at the Pikes Peak Inn, within Sub Reach 7c.

In the interim, some minor hand work may be done in this segment with volunteer hand crews to stabilize the left (south) stream bank, particularly where the river has undermined the root systems of several large cottonwood trees. Boulders will be lowered into the channel from Lover's Lane using an excavator, and these will be positioned by hand crews along the left bank adjacent to these trees to reduce further undercutting of the root systems. This work will lessen the chance of complete failure of the root systems during high flows, and the subsequent risk of clogging of the channel with this large wood.



Photo 18: The severely confined segment of Fountain Creek adjacent to Lover's Lane.



Plan view of habitat enhancements and bank stabilization within Sub- Reach 7d of Fountain Creek within Mansions Park.



## Restoration Plan for Sub-Reach 7d – Stage Coach Inn / Wichita Parking Lot

The drop structure at Pool 13 may present a barrier to trout migration through the reach. This structure consists of a metal plate placed diagonally across the stream channel, with the right end embedded into a concrete retaining wall and the downstream left side firmly embedded into the stream bank. A demolition saw will be used to cut a 16” wide by 8” deep notch in the plate to create a lower hydraulic jump between the pool downstream and the pool upstream of this feature, facilitating migration upstream. While it may be preferable to completely remove this feature, we are concerned that a head-cut could migrate up through this segment of the reach, with undesirable consequences to the relatively good quality pools immediately upstream. Removing even a portion of this drop structure could increase the risk of head-cutting, therefore it is recommended that another boulder cross-vane be installed at the transition between Pool 14 and Riffle 18 to eliminate this risk. This boulder cross vane will be configured to relieve shear forces on the right bank retaining wall, where a back eddy is undermining the foundation of the wall. The wall foundation will be protected by 24”- 30” rip-rap boulders where it has failed, immediately below a storm water culvert.



Photo 19: Fountain Creek adjacent to the Stage Coach Inn, looking upstream.

Pocket water cover in Riffles 19, 20 and 21 will be increased and enhanced using the same techniques employed downstream; adjusting existing boulders as necessary and installing up to ten boulder micro-vortex structures. Two boulder rock vanes will be installed along the foundation wall of the Stage Coach Inn, where a lateral scour pool has begun to form immediately adjacent to the foundation footings. These boulder vanes will reduce shear forces along the foundation wall during high flows, as well as provide velocity shelter and fish viewing opportunities for guests dining on the deck of the restaurant immediately above this pool.

While the stream banks are mostly in relatively good condition in this segment, bare and eroded areas adjacent to the right stream bank, below the Wichita Parking Area, will be re-vegetated by RMFI work crews using transplanted sedge along the stream green-line, and native upland grasses and forbs on the slopes leading up to the parking area. Up to two access paths to the stream, with stone steps, will be constructed to allow public access to the stream along this segment.

#### **Project Implementation Schedule:**

Preliminary estimates are that this work would take approximately three to four weeks to complete, and would require the use of a 20-35K lb excavator with a hydraulic thumb and a front end loader. We estimate that 530 - 550 boulders (265 yd<sup>3</sup>) will likely need to be imported into the site in order to complete the work. Additionally, approximately 25 cottonwood or other trees, averaging 10"-16" DBH, will need to be secured to complete the toe-slope stabilization and riparian benching work. There is no available riparian plant species on site, so willow and sedge will need to be imported from other areas of the Fountain Creek watershed downstream. Current harvest sites under consideration are from areas scheduled for riparian vegetation maintenance by Colorado Springs Storm Water Enterprise on Camp Creek, Monument Creek and Fountain Creek. A preliminary budget estimate for completing habitat enhancements in Reach 7 is included in the appendix. This estimate should not be construed as a fixed cost proposal to complete the project by FIN-UP Habitat Consultants, Inc., and is provided solely for planning and fund-raising purposes for the City and the Fountain Creek Restoration Committee (FCRC).

#### **Goals and Objectives of Habitat Restoration in Reach 7**

- Greater sediment transport efficiency, as measured by increased maximum pool depth, residual pool depth and total volume within newly constructed pools within the reach.
- 320 feet of eroding stream banks stabilized and re-vegetated. 150 feet of the stream completely restored, with defined stream banks and increased sinuosity. Approximately 4,500 ft<sup>2</sup> of bare stream banks and bank slopes will be re-vegetated using native riparian and upland plant species.
- 1/2 Acre of improved in-stream and stream bank riparian habitat along 1545 feet of Fountain Creek, including 11 Cross-Vanes to create or enhance pool habitats, 3 J-Hook Rock Vanes to provide additional pool habitat, and up to 40 rock clusters to provide pocket water holding and feeding areas and velocity shelter within the riffle habitats of the reach.
- Improved educational and recreational opportunities within the park.
- Create multiple fish viewing areas within the park. Install interpretive sign describing aquatic/riparian ecosystems.

## **Glossary of Terms:**

**Benthic Zone** - The benthic zone is the lowest level of a body of water. It is inhabited mostly by organisms that tolerate cool temperatures and low oxygen levels, called benthos or benthic organisms.

**Cascade** - A meso-habitat type. Cascades are the steepest riffle habitat types, in terms of gradient, in streams. These riffles consist of alternating small waterfalls and shallow pools. These habitats may appear to have the characteristics of a Step-pool system. Cascades are characterized by swift current flows and often have exposed rocks and boulders above the water surface, which creates considerable turbulence and surface agitation. The substrate normally found in cascades is bedrock or accumulations of boulders.

**Cover** - Locations where fish prefer to rest, hide and feed are called cover. Cover serves to visually isolate fish, which increases the number of territories in the same space. Additionally, cover can create areas of reduced velocities providing critical resting and feeding stations for fish. The amount of cover available in a stream can influence the production of a number of fish and invertebrate species.

**Cross-Vane** - A structure spanning the entire width of the channel, constructed of large boulders and/or large wood, that provides vertical stability, increased scour, increased stage upstream, and reduced stream power. This structure type is commonly used as a diversion structure for irrigation ditches, as well as for treating active down cutting and head cuts in the stream channel.

**Embeddedness** - The degree to which the interstitial spaces between larger substrate particles are filled with finer sediments. Embeddedness tends to armor the substrate, thus limiting available habitat for benthic dwelling macroinvertebrates and spawning habitat for salmonids.

**Glide** - A meso-habitat type. Glides are those portions of streams which have relatively wide uniform bottoms, low to moderate velocity flows, lack pronounced turbulence, and have substrates usually consisting of either cobble, gravel or sand. Glides are usually described as stream habitat with characteristics intermediate between those of pools and riffles. These habitats are commonly found in the transition between a pool and the head of a riffle, however they are occasionally found in low gradient stream reaches with stable banks and no major flow obstructions.

**Green Line** - A narrow band of riparian plant species immediately adjacent to the stream bank in deeply entrenched streams. These are typically streams that have no identifiable flood plains.

**Head-Cut** - An area of active down-cutting in the channel where a river or stream is eroding down to a new, lower flood plain.

**Intermittent** - An intermittent stream is one that only flows for part of the year.

**Lotic** - Of, relating to, or living in moving water such as streams and rivers.



**Meso-Habitat** - A channel scale habitat form. Typically a pool, riffle, rapid, cascade or glide habitat. A meso-habitat occupies the entire width of the stream channel, and with few exceptions (most notably plunge pools in high gradient step-pool systems) is at least as long as the channel is wide.

**Micro-Habitat** - Micro habitats are small, site specific habitats within a meso-habitat form, and may include spawning redds, in-stream or overhead cover, and velocity shelters.

**Micro-Vortex** - A small rock cluster structure that replicates pocket water habitat in riffles, rapids and cascades.

**Over-Wintering Habitat** - Areas of a stream or water body exhibiting depths that may sustain a population through the winter months.

**Perennial** - A perennial stream is one that flows year round.

**Pocket Water** - A micro-habitat type. Pocket water habitats are typically found in higher gradient riffles, rapids, and cascades with large cobble, boulder, and large woody debris. These pocket water habitats provide small areas for velocity shelter and cover within these fast-water habitat forms.

**Pool** - A meso-habitat type. Pools are channel segments exhibiting areas of scour and deposition where the water is deeper and slower moving.

**Primary Producers** - Primary producers are those organisms in an ecosystem that produce biomass from inorganic compounds. In almost all cases these are photosynthetically active organisms.

**Rapid** - A meso-habitat type. Rapids are riffles associated with high gradients (greater than 4%) with swiftly flowing (greater than 1.5 ft/sec), moderately deep, and highly turbulent waters. These riffles are generally associated with boulder substrates, which protrude through the surface of the water.

**Residual Pool Depth (RPD)** - Residual pool depth is estimated as the depth of water which would be retained in a pool under highly reduced flows or the stoppage of flows in the stream. This area of pools would be utilized by fish in low flow conditions. Residual pools would also provide habitat for overwintering of fish when ice buildup restricts movement in riffles or glides between pools. Residual pool depth is calculated by locating and measuring the greatest depth of the pool at the riffle crest (deepest point of the downstream boundary cross-section of the pool), and subtracting this value from the greatest measured depth of the pool habitat. The difference in these measurements is described as the RPD. RPD may be difficult to determine in some habitats, particularly dam pools with woody debris structural associations. In many of these habitat units, the RPD may actually be a very low value or zero due to water flowing through these debris dams.

**Riffle** - A meso-habitat type. Riffles are those areas of the stream in which turbulence in the water column is the major identifying characteristic, as a result of relatively high gradients. These units contain moderately deep to shallow, swift flowing water, and are characterized by boulder or cobble substrates. Riffles are very important for macroinvertebrate production, due to the availability of light and oxygen, and the corresponding vegetative growth on the bottom substrate. The quality of riffles, including low sediment deposition and resulting embeddedness can have a direct impact on fish populations. The cleaner and healthier the vegetative growth and benthic macroinvertebrate community, the more food there is for the fish population.

**Salmonids** - Salmonidae is a family of ray-finned fish, the only family of order Salmoniformes. It includes the well-known salmon and trouts; the Atlantic salmon and trouts of genus *Salmo* give the family and order their names.

Subfamily - Salmoninae

Brachymystax - lenoks

Oncorhynchus - Pacific salmon and trout

Salmo - Atlantic salmon and trout

Salvelinus - Char and trout (Brook trout, Lake trout)

**Substrate** - Stream substrate (sediment) is the material that rests at the bottom of a stream.

**Thermal Refugia** - Micro habitats found in streams and lakes that provide thermal protection for cold water species such as trout. These may include shaded areas, cool water springs, and deep water habitats.

**Toe-Slope** - The foot, or bottom, of the sloping bank of a stream. This is the area of the highest sheer stress and erosion potential on a stream bank, and is typically the point of failure leading to mass wasting and collapse.





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